Algebra of Syntactic Characters

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ABSTRACT: *We develop an algebraic model for establishing a relationship between 's', the type of sentences, and 'n', the type of names. Using these two basic categories of Generalized Categorial grammar, we develop other categories for any given expression. This would afford a ready tool to identify a sentence in an expression and determine an expression that cannot be classified as a sentence, i.e., non-sentence.*

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1. Introduction

A lot of authors have researched into the structure of sentences [3] and deployed the concept of Generalized Categorial Grammar to transform and modify words. They used the two basic categories to develop other categories, some of which would be utilized in this work. [5] Some have looked at sentence structure from the transformation point of view. They developed a model that could be used to transform a sentence from active voice to passive voice. In [1], a simpler method of syntactic description was developed, using what is called as'quasi-arithmetic characters', in which created categories were assigned to linguistic string to enable the computation of syntactic character. It should be noted here that this method may not be suitable for all languages, but it provides succour to some, English being the major one. The problem of proper formalization of human language or universal grammar is still an open one. In this work, we develop the algebra of syntax which gives a simpler way of determining when a string of words is a sentence. The method would apply in all languages if the correct syntactic index is given to each member of the string of words.

2. Preliminaries

In this section, we shall utilize the definition in [2], and adopt symbols in [1] to develop others. Let us recall that in [6] grammar of English is said to be made of patterns and these patterns described sentence. So, sentence is made of patterns of either article-noun- verb or article- noun- verb- article- noun. In [4], sentence structure is of the pattern SVO (Subject – Verb – Object) or OVS (Object – Verb – Subject). This is used to identify sentences that are either active voice (SVO) or passive voice (OVS).

In what follows, we shall use the Context-free Phrase Structure Grammar or simply Context-free Grammar (CFG) to develop our sentence structure. The CFG is divided or partitioned into; grammatical category and a set of algebraic rules. The grammatical categories grouped the grammar into phrasal parts. A sentence for example can consists of a noun N and a verb V. A typical and simple example is *David laughs.* Here '*David'* is a noun and '*laughs'* is a verb. Noun can also be divided into noun phrase (NP) which in turn can be expressed as adjective, noun and a verb phrase (VP). These phrases can further be analysed as shown below;

$S \rightarrow NP\ VP$

$NP \longrightarrow (D)\ A^*\ N\ PP^*$

$VP \longrightarrow V\,(NP)\,(PP)$

$PP \longrightarrow P\ NP$

b. Lexicon:

D: the, some

A: big, brown, old

N: birds, fleas, dog, hunter

V: attack, ate, watched

P: for, beside, with

A set of algebraic rules are developed to express these grammatical categories. These rules help to develop sentence structure.

3. The Algebra of Syntax

Adopting the classical Categorial grammar basic categories, let s denote sentence and n (noun). Other categories would be derived from these basic categories. We shall rely on the following mathematical principle;

Proposition

Let e, s and n be given algebraic entities, then

i. $ne = n = en$ and $se = s = es$

ii. $n^{-1}n = e = nn^{-1}$ and $s^{-1}s = e = ss^{-1}$

iii. $(n^{-1}s)^{-1} = s^{-1}n$ and $(sn^{-1})^{-1} = ns^{-1}$

Note:
Simple algebraic computation using the proposition is given as follows;

$n\,(n^{-1}s) = nn^{-1}s = es = s$ and $s\,(n^{-1}s)^{-1} = s\,(s^{-1}n) = ss^{-1}n = en = n$

Computations like the above result in the Categorial index given in the table below.

The table [1] is developed in the following way; the name Peter is a noun and we assign n to it. The word honest is an adjective and added to Peter on the left, it becomes Honest Peter and modifies the noun Peter we assign nn^{-1}making it a noun operator. That is,

Peter = n. Honest Peter is a noun phrase and so Honest must be assigned nn^{-1}. In computation, we have Honest Peter $= nn^{-1}$(= Honest) n(Peter) $= nn^{-1}n = en = n$. The followings are examples demonstrating this concept.

n: {he; girl ; lunch; ...}, nn^{-1}: {good; the; eating; ...}

Category	Categorial Index	Language expression	Syntactic Index
Sentence	s	The rose blooms	s
Name (Noun)	n	Socrates	n
Common Name	sn^{-1}	Rose, Bear, Duck	sn^{-1}
Nominal, term	$s(ns^{-1})$	nobody, the rose	$s(ns^{-1})$
Intransitive verb	sn^{-1}	bloom, laugh	sn^{-1}
Modal verb	$(sn^{-1})(ns^{-1})$	can, must	$(sn^{-1})(ns^{-1})$
Attributive Adjective	$sn^{-1}ns^{-1}$	big, small	$sn^{-1}s^{-1}$
article	$\mathrm{sns}^{-1}\mathrm{ns}^{-1}$	a, an	$sns^{-1}ns^{-1}$
adverb	$sn^{-1}ns^{-1}$	strongly, loudly	$sn^{-1}ns^{-1}$
Sentence operator	ss^{-1}	not, necessary that	ss^{-1}
Intransitive verb	$(ns^{-1})^{-1}$	works	$(ns^{-1})^{-1}$
Noun operator	nn^{-1}	poor	nn^{-1}
adverb	$(ss^{-1})^{-1} = (ns^{-1})^{-1}((ns^{-1})^{-1})^{-1}$	here	$(ss^{-1})^{-1}$
Transitive verb	$(sn^{-1})^{-1}n$	have, likes	$ns^{-1}n$

Table from [1]

ns^{-1} : {sleeps; ate; eating; ...}; $(ns^{-1})n^{-1}$: {sees; ate; ...}

$s^{-1}s$: {quickly; today...}; $(ns^{-1})(ns^{-1})^{-1}$: {good; the;...}

Note:

1) If a word is added on the left to another word or sentence and does alter the part of speech of the word we write n n^{-1} and for the sentence, we write s s^{-1}. If a word is added on the right of a word or sentence, we write n^{-1}n or s^{-1}s. This is demonstrated in Honest Peter and Peter runs quickly.

2) Using table [1], we assess a collection of words to determine if it a sentence or non sentence. To this, we identify each word with the algebraic syntax given and using the proposition above, to do the algebraic computation, if the result is s, then the collection of word is a sentence. For example; 'The rose blooms'. This a sentence and we can express it in terms of algebraic syntax to verify it as follows; $s\,(ns^{-1})$ (= The rose) sn^{-1} (= *blooms*), that is,

$s\,(ns^{-1})\,sn^{-1} = sns^{-1}sn^{-1}$. Here, we open the bracket.

$= sn\,(s^{-1}s)\,n^{-1}$, here we re-insert the bracket

$= snen^{-1}$, we apply the proposition, that is, $s^{-1}s = e$.

$= s\,(ne)n^{-1}$, here, we re-insert the bracket

$= snn^{-1}$, we apply the proposition, that is, $ne = n$.

$= se = s$.

So, 'The rose blooms' is a sentence.

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